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Laser Ablation as an Enabling Technology for the Structuring of Optical Multilayer Structures

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In this paper, laser ablation is presented as a versatile technology that can be used for the fabrication of all building blocks and functional elements required for an optical interconnection, integrated in printed circuit boards (PCBs). This integration of optical interconnections in PCBs is an emerging field in which interest worldwide is rapidly growing. Limiting factor is mainly the compatibility of new technologies, used to define and fabricate the optical interconnections, with existing and standard FR4-processing steps, temperatures and lamination pressures. Laser ablation, which is currently frequently used for drilling of electrical micro-vias in PCBs, has proven to be fully compatible with standard PCB manufacturing. The laser ablation set-up available at our institute contains three different laser sources: a KrF-excimer (248nm), frequency tripled Nd-YAG (355nm) and CO_2 laser (9.6µm), which allow us to structure a large variety of materials. The sample is placed, during the processing, on a computer-controlled translation table, which has an accuracy of 1µm. The excimer laser can be tilted, which eases the definition of angled facets considerably. The laser ablation set-up can be used for the definition of multimode waveguides, deflecting optics, refractive lenses and alignment marks [1].

Fiber-based interconnections, integrated in PCBs, are already commercially available, but the fiber-in-board approach has some serious short-comings as it results in expendable assembly processes being unsuitable for high volume production at reasonable costs. A better solution is the integration of optical layers that contain the optical waveguides as well as all passive optical structures, in a PCB. The optical layer has to be compatible with standard PCB manufacturing, which means that it has to withstand lamination and soldering processes. The commercially available optical material, Truemode™ backplane polymer in our case, is chosen in view of its excellent optical, thermal and planarization properties. The multimode waveguides are defined using the frequency tripled Nd-YAG laser and result in smooth sidewalls, which are necessary to obtain a low propagation loss. Deflecting 45° total internal reflection (TIR) micro-mirrors are used for the coupling of the light in and out of the plane of the waveguides. These micro-mirrors are defined using the excimer laser. A certain degree of tapering is observed; however the tapering angle can be measured and corrected for. Surface roughness measurements are performed on both the waveguides and the micro-mirrors with a non contact optical profiler.

We report on the realization of a two layer structure that contains waveguides and micro-mirrors. The stacking of multiple waveguide layers allows us to explore the functionality of 2D optoelectronic elements such as VCSEL and photodiode arrays to the fullest extend, and thus increase the integration density. The alignment between the waveguides in the different layers is critical. Alignment marks are defined in the same step as the micro-optical elements. The sample can stay on the translation table during the processing, which increases the alignment accuracy. Refractive micro-lenses can be integrated to further increase the coupling efficiency.

[1] G. Van Steenberge, P. Geerinck, S. Van Put, J. Van Koetsem, H. Ottevaere, D. Morlion, H. Thienpont, and P. Van Daele, "MT-Compatible Laser-Ablated Interconnections for Optical Printed Circuit Boards", Journal of Lightwave Technology, Vol. 22, No. 9, September 2004

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